Applied Meteorology Unit   Memorandum

TO: **William Roeder, 45th Weather Squadron**
                 Richard Lafosse, Spaceflight Meteorology Group
                 David Sharp, National Weather Service, Melbourne

FROM: **Mark M. Wheeler and David A. Short**

SUBJECT: **Phase III: Improved Anvil Forecasting**

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Approved For Distribution:

signed
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Dr. Francis Merceret

1.   Introduction

1.1   Purpose of Memorandum

The 45th Weather Squadron (45 WS), Spaceflight Meteorology Group (SMG) and the National Weather Service Office at Melbourne (NWS MLB) tasked the Applied Meteorology Unit (AMU) to expand the anvil threat sector tool developed under Phase II by adding functionality to display a forecasted threat sector based on the Eta and Medium Range Forecast (MRF) model point data. In response, the AMU developed a utility that uses Eta and MRF model point data to display a forecast threat sector out to 168 hours. This memorandum documents the Phase III effort and provides instructional material for using the utility in an operational setting.

1.2   Background Information

The 45 WS Launch Weather Officers (LWOs) have identified anvil forecasting as one of their most challenging tasks when predicting the probability of a Launch Commit Criteria (LCC) violation due to the threat of natural and triggered lightning. SMG forecasters have reiterated this difficulty when evaluating Space Shuttle Flight Rules (FR).

1.2.1   Phase II Development

Phase I of this task established the technical feasibility of developing an objective, observations-based tool for short-range anvil forecasting. The AMU was subsequently tasked to develop short-term anvil forecasting tools to improve predictions of the threat of triggered lightning to space launch and landing vehicles. Under the Phase II effort, the AMU developed a nowcasting anvil threat sector tool, which provides the user with a threat sector based on the most current rawinsonde upper wind data from a co-located or upstream station. This tool is currently used operationally by the 45 WS LWOs and SMG forecasters.

1.2.2 Phase II Anvil Threat Sector Tool

The Phase II Anvil Threat Sector tool computes the average wind speed and direction in the layer between 300 and 150 mb from the latest sounding for a user designated station.   The following threat sector properties are consistent with the propagation and lifetime characteristics of thunderstorm anvil clouds observed over Florida and its coastal waters (Short et al. 2002):

20 n mi standoff circle,

30 degree sector width,

Orientation given by 300 to 150 mb average wind direction,

1-, 2-, and 3- hour arcs in upwind direction, and

Arc distances given by 300 to 150 mb average wind speed.

Figure 1 is an example of the Anvil Threat Sector tool overlaid on a visible satellite image at 2132 UTC 13 May 2001. Space Launch Complex 39A was selected as the center point and the Anvil Threat Sector was determined from upper-level wind data at 1500 UTC in the pre-convective environment. Narrow thunderstorm anvil clouds extend from central Florida to the space launch and landing facilities at the Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS) and beyond. The anvil clouds were generated around 1930 UTC (1430 EDT) by thunderstorm activity over central Florida and transported 90 n mi east-northeastward within 2 hours, as diagnosed by the anvil forecast tool.
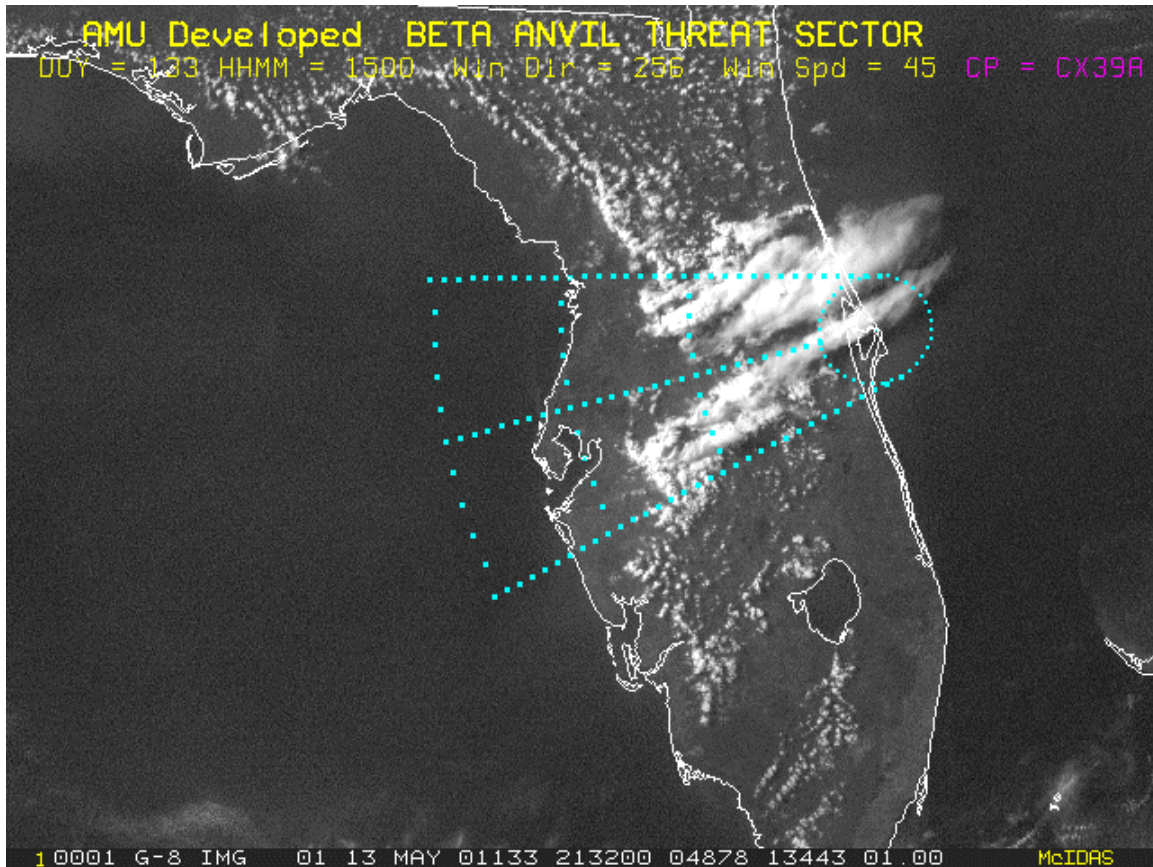

Figure 1. Example of the Phase II anvil forecast graphic overlaid on a visible satellite image of the Florida peninsula. The Anvil Threat Sector was computed from radiosonde data observed at XMR at 1500 UTC (1100 EDT) 13 May 2001. Thunderstorms that formed within the graphical threat sector produced anvil clouds that moved over the KSC/CCAFS area.

2.   Phase III: Enhanced Graphic Product Development

The following sections provide information on the products selected for development under Phase III and the results of the development effort. The goals of Phase III were to build upon the results of Phase II by enhancing the Anvil Threat Sector tool with the capability to use national model forecast winds for depiction of potential anvil lengths and orientations over the KSC/CCAFS area with lead times from 3 through 168 hours (7 days). Data are available approximately 3 hours after model initialization time.

2.1 Phase III Development

The Anvil Threat Sector tool developed in Phase III is a Man Computer Interactive Data Access System (McIDAS) McIDAS BASIC Language Interpreter (McBASI) script that uses an average of the upper-level winds between 300 and 150 mb from either the most current Eta or MRF model point data to plot its threat sector, depending on the forecast verification time. The forecast Anvil Threat Sector can be displayed every hour from 3 – 60 hours using the Eta point data and every 12 hours from 72 to 168 hours using wind data from the MRF point data.

Figure 2 shows an example of the Phase III display tool of the forecast Anvil Threat Sector. Input from the user centered the plot on Space Launch Complex 37 (SLC-37) and specified a forecast hour 26 using upper-level winds from the Eta model point data. On the top right is a legend that shows the model used, the Julian date, and the UTC time of the model input, mean 300 to 150 mb forecast wind direction and speed, and the center point.
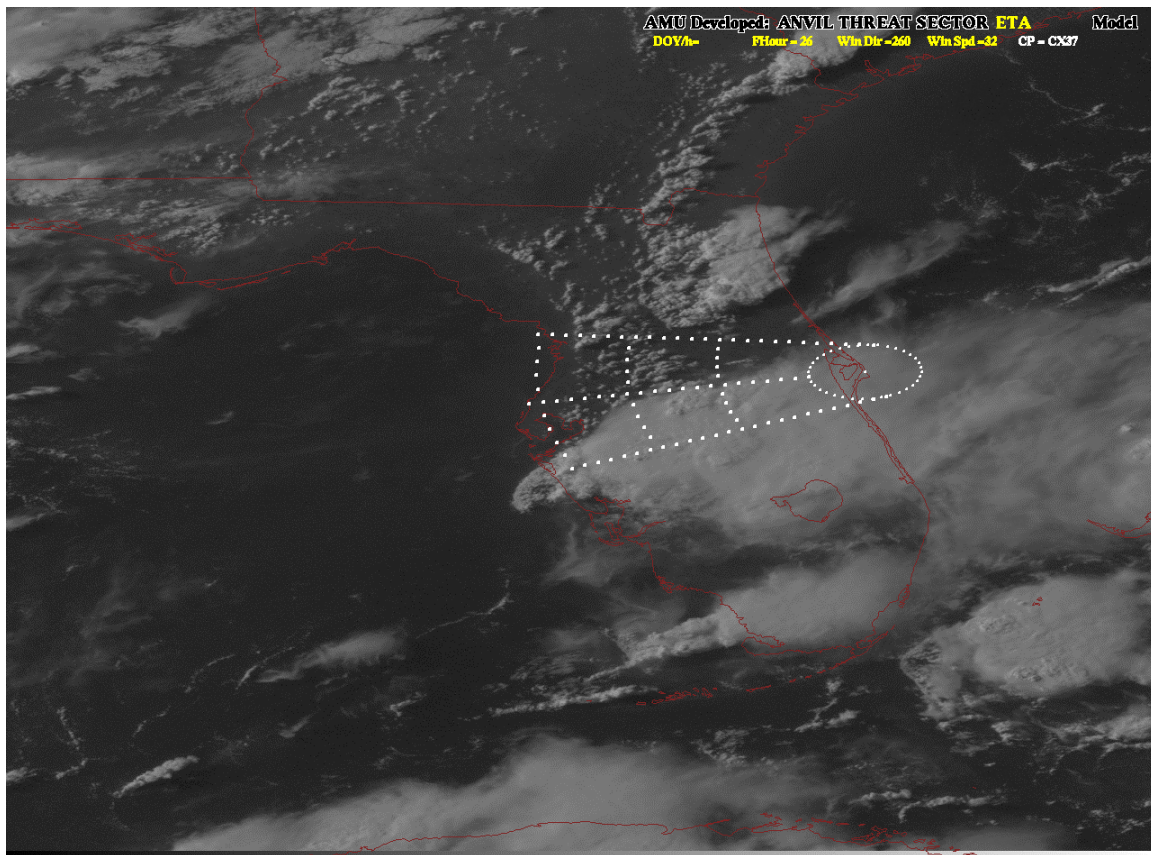

Figure 2. Example of the Anvil Threat Sector using the Phase III forecast Anvil plotting utility. The white dots highlight the Anvil Threat Sector centered on SLC-37, derived from the 26-hour forecast of upper level winds from the Eta model point data.

The two utilities (Phase II and III) can be used together to view a current day and future threat (Figure 3). During an operation, the LWO can display the current Anvil Threat Sector and then view the forecast

changes based on input from either the Eta or MRF point data. This tool could help improve the 24- and 48-hour scrub forecasts if convection is a concern.
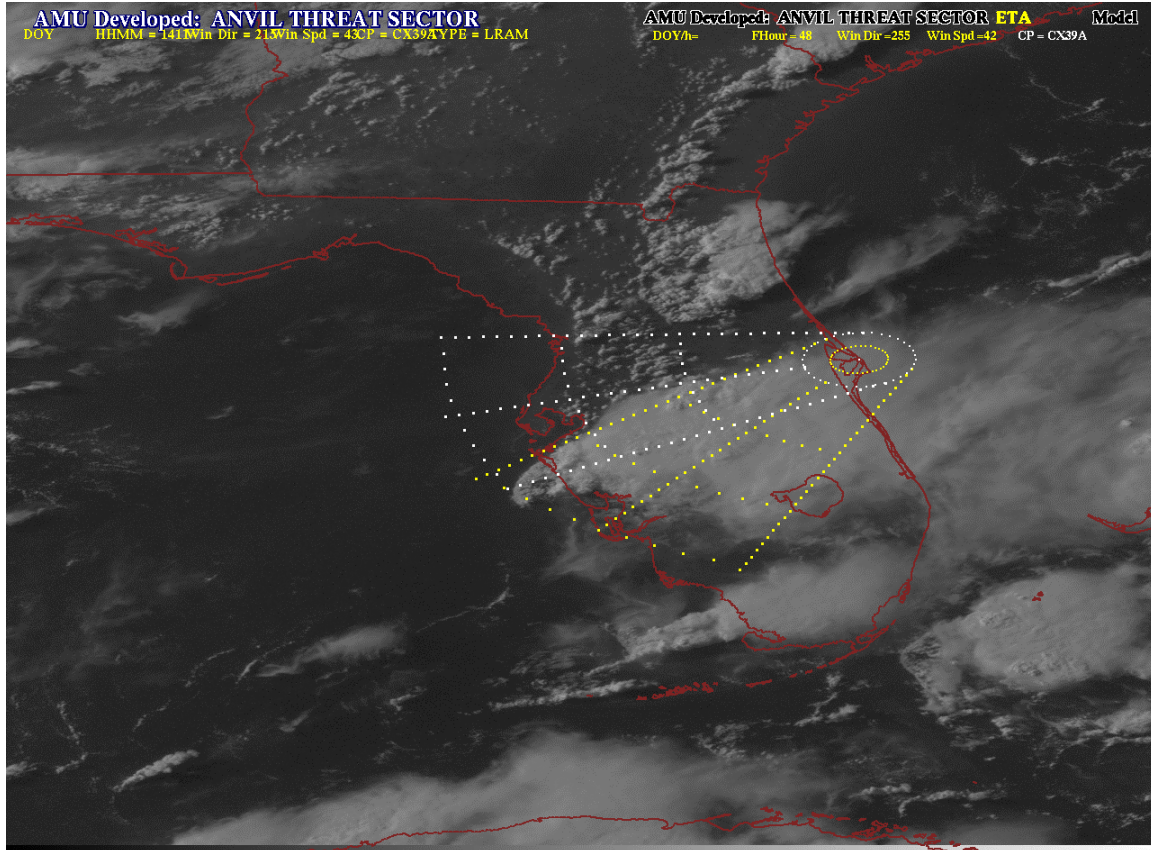

Figure 3. Example of overlaying the Phase II and III Anvil Threat Sector plotting utilities. The yellow dots highlight the Phase II Anvil Threat Sector centered on SLC-39A, and the white dots are a 48-hour anvil forecast threat sector using upper level winds from the Eta point data.

2.2   Implementation

The Forecast Anvil Threat Sector tool based on Eta or MRF model point data was written as a McBASI script that will run on McIDAS workstations. It has been tested on 45 WS and SMG McIDAS display systems. A command line help function was written into the utility to allow the user to quickly see the command line requirements. The script was also designed so that it does not generate lingering McIDAS processes on the system, thereby requiring a minimum of operator attention.

3.   Training

The AMU will provide one-on-one training for LWOs and SMG forecasters to familiarize them with the use of the forecast Anvil Threat Sector tool on McIDAS. The McBASI script contains a "HELP" section that can be accessed by issuing the following command line:

HELP ANVILFCST

Table 1 lists the McIDAS command line options for executing the anvil forecast tool. The command is "ANVILFCST" followed by up to four optional fields (listed as Var. 1-4 in Table 1). Variable two defines the forecast hour, variable three defines the output line, and variable four defines the plot sector and text color. The default command with no optional fields centers the threat corridor on the Shuttle Landing Facility (SLF), uses the 12-hour forecast upper-air data from the Eta model, and plots the forecast sector and output information on display line one using color 3 (yellow).

The user can select other center point locations in the KSC/CCAFS area and beyond by entering a station ID found in the Eta or MRF point model database as variable one. The user can view this list by entering "PTLIST RTPTSRC/ETA00 SELECT='FCST 0;SIGL 1' PARAM=CSTA LAT LON NUM=ALL" on the McIDAS command line. It will display a listing of available station IDs and latitude/longitude center points. Table 2 is a listing of station ID, state and latitude/longitude points available to the 45 WS RWO.

Table 1. McIDAS command line options for running the anvil forecast tool.					
McIDAS Command Line	Var. 1	Var. 2	Var. 3	Var. 4	Plot Description
ANVILFCST	N/A	N/A	N/A	N/A	Eta 12 h, SLF
ANVILFCST CX17 6 2 3	CX17	6	2	3	Eta 6 h, CX17, Ln 2, Color 3
ANVILFCST CX17 72 1 2	CX17	72	1	2	MRF 72 h, CX17, Ln 1, Color 2
ANVILFCST KEDW 32 3 3	KEDW	32	3	3	Eta 32 h, KEDW, Ln 3, Color 3

Table 2. 45 WS plotting station information.							
Station ID	State	Latitude	Longitude	Station ID	State	Latitude	Longitude
KIAH	TX	29.97	95.35	KMIA	FL	25.82	80.28
KXMR	FL	28.47	80.55	KJAX	FL	30.50	81.69
KEDW	CA	34.92	117.9	KCTY	FL	29.62	83.10
KWSD	NM	32.24	106.22	KMCO	FL	28.43	81.32
KLCH	LA	30.12	93.22	KAGR	FL	27.65	81.33
KCRP	TX	27.77	97.50	KFMY	FL	26.58	81.87
KHAT	NC	35.27	75.55	KPBI	FL	26.68	80.12
KBNA	TN	36.13	86.68	KTBW	FL	27.70	82.38
KGSO	NC	36.08	79.94	KNSI	CA	33.25	119.45
KDSC	CA	35.34	116.88	KHOU	TX	29.65	95.28
KAHN	GA	33.95	83.32	KBNV	UT	40.20	113.30
KCKL	AL	32.90	87.25	KMIB	NC	48.50	101.40
KTLH	FL	30.38	84.37	KPOB	NC	35.17	79.02

4.   Summary

This memorandum documented the development and implementation of a short-range anvil forecast tool designed by the AMU for operational use on McIDAS by 45 WS LWOs and SMG forecasters. Phase I of this task established the technical feasibility of developing an objective, observations-based tool for short-range anvil forecasting. The AMU was subsequently tasked to develop short-term anvil forecasting tools to improve predictions of the threat of triggered lightning to space launch and landing vehicles. The Phase II effort involved the development of a nowcasting Anvil Threat Sector tool, which provides the user with a threat sector based on the most current rawinsonde upper wind data from a co-located station. Finally, Phase III expanded upon the Phase II tool, providing a graphical tool that allows the user to present a forecast Anvil Threat Sector from 3 to 60 hours using the Eta point data, as well as 72 hours and beyond using the MRF point data.

5.   References

Lambert, W. C., 2000: Improved Anvil Forecasting: Phase I Final Report. NASA Contractor Report CR-2000-208573, Kennedy Space Center, FL, 24 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL, 32931.]

Short, D. A. and M. M. Wheeler, 2002: Improved Anvil Forecasting: Phase II Final Report. NASA Contractor Report CR-2002-211170, Kennedy Space Center, FL, 19 pp. [Available from NASA, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL 32931.]

Short, D. A., J. E. Sardonia, W. C. Lambert, and M. M. Wheeler, 2002: Propagation and lifetime characteristics of thunderstorm anvil clouds over Florida. Preprints, *18th International Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography and Hydrology*, Orlando, FL, 19 - 21.

6.   Appendix A. ANVILFCST Help File

Listed below is an example of the ANVILFCST help file available to the user by entering `HELP ANVILFCST' from the command line within the MIDDS Text Window.

--==[[Applied Meteorology Unit (AMU) Developed Anvil Threat Tool]]==--

 ANVILFCST -- Plot Anvil Threat Corridor on Image based on ETA or MRF Point Data
         All keyins are entered from the MIDDS Text Window
         ---> Uses Model Point Data;
              ETA from   3 - 60 Hours, interval every 1 hour
              MRF from 72 - 240 Hours, interval every 12 hours

   Command line: ANVILFCST *Stn*(see below) *HR*(3-240) *Color*(1-7) *Line*(1-3)
                   Defaults are; Stn SLF, HR 12, Color 3, Line 1

 Stn CX17, CX36 CX37, CX39, CX40, CX41, MLB, KTLH, CTY, KJAX, TBW, KMCO,
    AGR, KFMY, KPBI, KMIA, KIAH, KHOU,EDW, WSD, KLCH, KCRP, KHAT,
    KBNA, KGSO, DSC, KAHN, KCKL, KNSI, KLCB, KBNV, KPOB, KMIB

 HR (Forecast hour) 3 to 240 (Default 12)
 Color   1, 2, 3, 4, 5, 6, 7 (for anvil sector (Default 3))
 Line   1, 2, 3 (for LABEL (Default 1))

 Keyin Examples: ANVILFCST CX37 12   (12 hr fcst, color 3 (default), line 1)
                   ANVILFCST KMCO 18 5 2 (18 hr fcst, color 5, line 2)
 ===
      TO get a listing of other ETA Point Stations (about 20) enter;
    PTLIST RTPTSRC/ETA00 SELECT='FCST 0;SIGL 1' PARAM=CSTA LAT LON NUM=ALL